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CASES ILLUSTRATIVE OF THE PRACTICAL APPLICATION OF THE RÖNTGEN RAYS IN SURGERY.

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The Röntgen method is, of course, in its infancy. It has, however, already reached a degree of usefulness that makes it obvious that the necessary apparatus will be an essential part of the surgical outfit of all hospitals and will be employed constantly in a variety of cases. Those to which the method can now be applied with advantage may be summarized as follows, emphasis being placed on the fact that what is written to-day may require revision or reversal to-morrow, so rapidly are improvements and discoveries taking place:

1. *Foreign bodies imbedded in any of the tissues of the body.* This is at once the most obvious and the simplest application of the skiagraph to surgery. Hundreds of cases have already been reported. Bullets, fragments of metal or of glass, needles, etc., are easily found, and, even if they are lodged in bone, the varying density of the shadows cast by substances of different permeability or of different chemical constitution will serve to define and locate them. It is desirable, if the foreign body be in a locality containing important surgical structures, that skiagraphs be made from at least two points of view, so that the depth from the surface and the exact relations of such body can be determined by measurement. A single skiagraph of a piece of steel in the arm, for example (Case X., Plate VIII.), taken from the front shows merely

its relation to the inner or outer edge of the arm, not at all its depth. A second view taken laterally would make the precise situation evident.

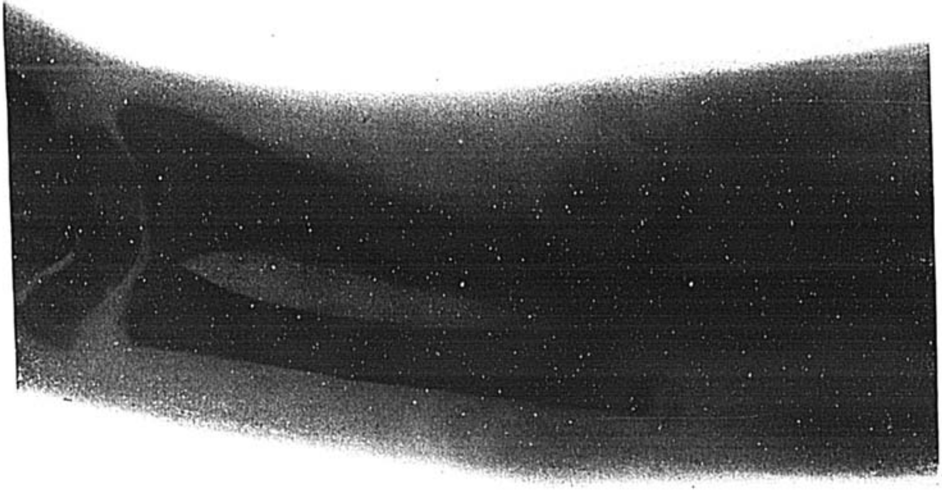
2. *Foreign bodies in certain of the organs and viscera* are likely to be discovered and located with a degree of accuracy that will vary with the region or structure involved and with the thickness of the enclosing tissue. Waggett and Rowland have shown (*British Medical Journal,* March 19, 1896) that a fish-bone and a small nail attached by plaster to the side of the neck in the position of the ventricle can be skiagraphed with ease. The larynx itself did not show at all, but by the aid of a chart of the region the exact position of a foreign body in the larynx ought to be easily determinable. It is obvious that extension of the method to the location of such bodies in the trachea, bronchi, and other portions of the air-passages is sure to come with further improvements in technique. In the digestive tract, except, perhaps, the first third of the œsophagus, the difficulties are greater; but the presence or absence of foreign bodies can doubtless be determined, although below the stomach it is questionable whether any definite information as to the exact situation can be obtained. In many cases, however, especially in children, it is a matter of grave doubt as to whether or not some foreign body has been swallowed. As the most uncertain cases occur in the youngest children, and as the ease of skiagraphy of the whole body is in direct proportion to the thinness and softness of the tissues, we may expect in just these cases to get the exact information which is so often lacking in the history given by anxious parents or nurses. Within the cranium neither experimental tests nor trials in actual cases have yet given any practical results in the discovery or location of foreign bodies, but there is every reason to believe that this will become possible in the near future.

3. *Foreign bodies formed within the organism itself* include chiefly gallstones and renal, vesical, and prostatic calculi.

Gallstones skiagraphed without the body cast very faint shadows; calculi of oxalate of lime, of phosphate of lime, and of triple phosphate cast shadows as dense as those of bone or metal; uric-acid calculi cast easily recognizable but somewhat fainter shadows (*British Medical Journal,* London, April 4, 1896).

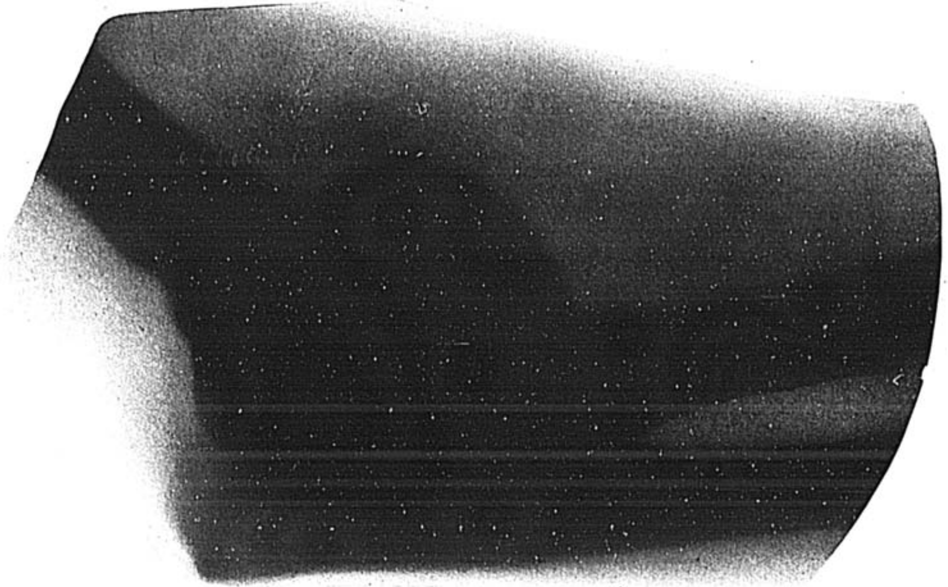
No practical results have yet been obtained in the discovery of these forms of calculi, but it seems within bounds to expect that after we become more familiar with the shadows cast by the normal viscera and the normal skeleton, we may be able to distinguish gallstones from malignant disease involving the ducts; may locate or exclude renal calculi in doubtful cases; and may see encysted vesical or prostatic calculi even through the shadows cast by the pelvic bones themselves. Many skiagraphs show in outline the shadow of one bone through the shadow of another (Case VI., Plate V.), and it is not improbable that after a time accurate diagnoses can be made in this manner. At present it is not possible.

PLATE I.



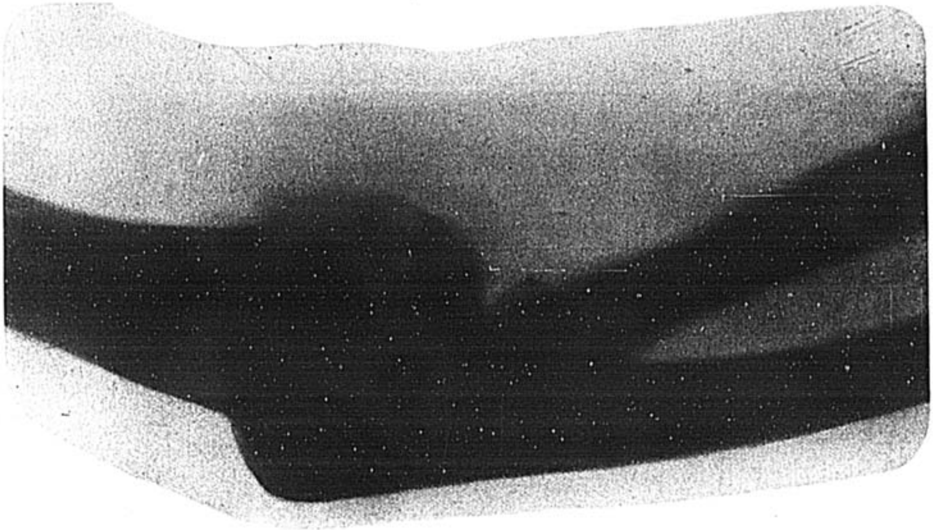
Case II. Ununited Fracture of Both Bones of the Forearm.

PLATE II.



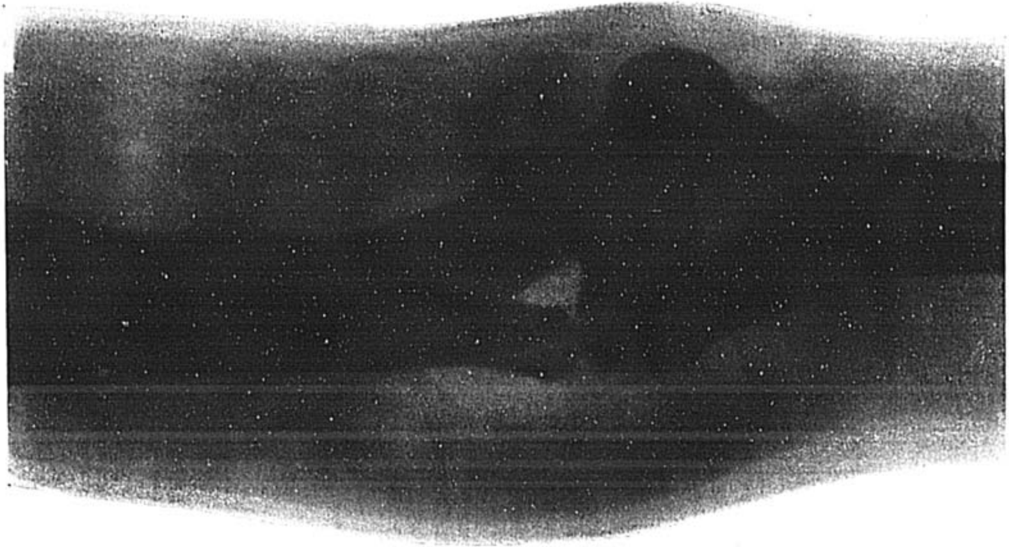
Case III. Dislocation of Both Bones of the Forearm Backward, with Ankylosis.

PLATE III.



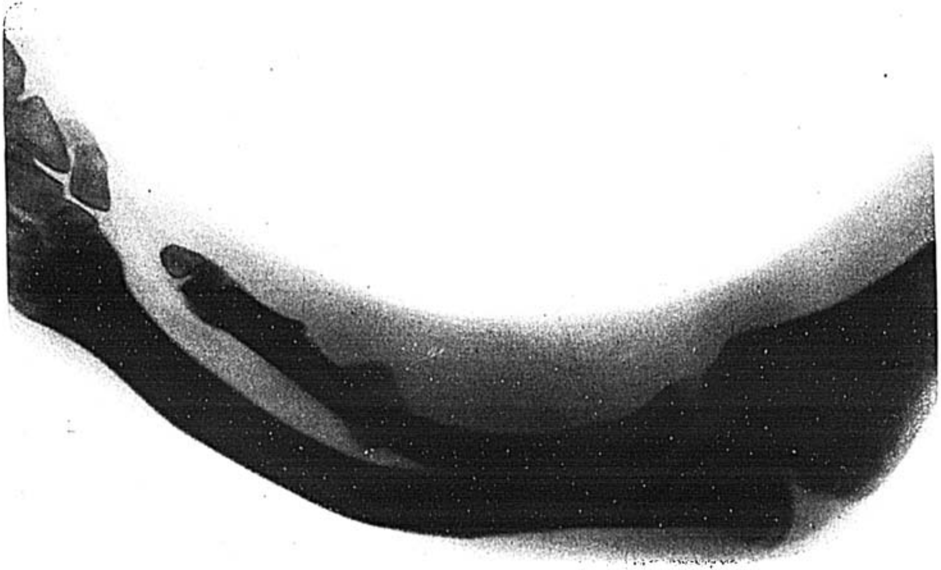
Case IV. Obscure Fracture Involving the Ulna and Humerus.

PLATE IV.



Case V: Excision of the Head of the Radius.

PLATE V.

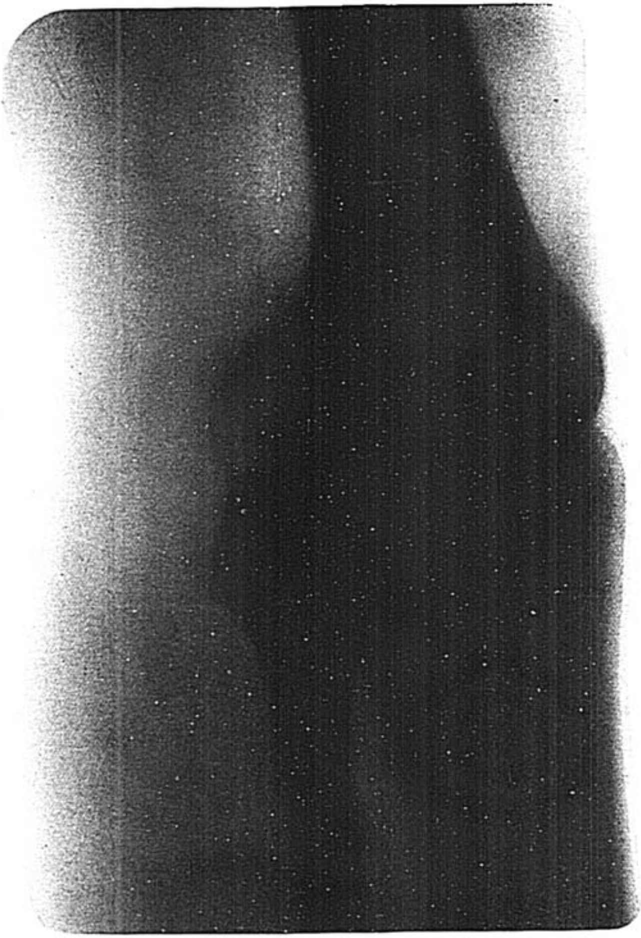


Case VI. Curvature of the Radius, due to Arrested Development of the Ulna at its Distal Epiphysis.

PLATE VI.

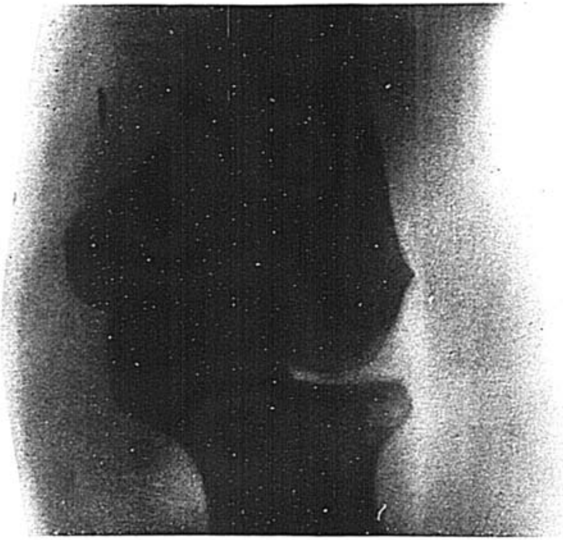
Case VII. Diastasis of the Distal Epiphysis of the Humerus.

PLATE VII.



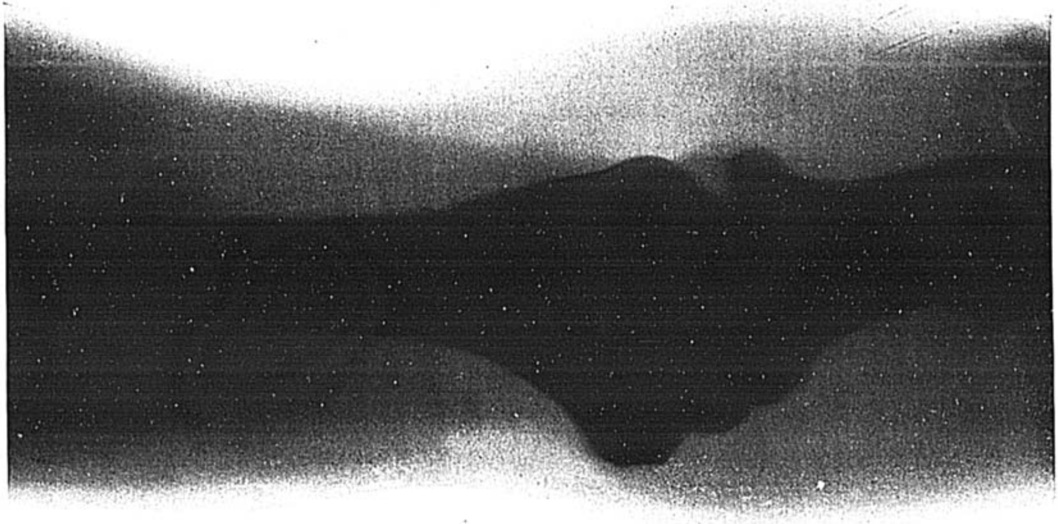
Case IX. The Results Obtained in Excision of the Knee.

PLATE VIII.



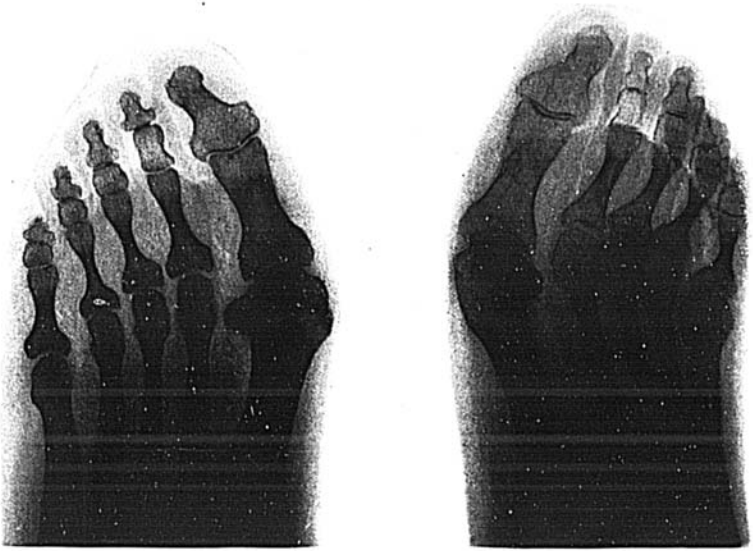
Case X. Foreign Body in the Arm.

PLATE IX.



Case XI. Bullet in Forearm.

PLATE X.

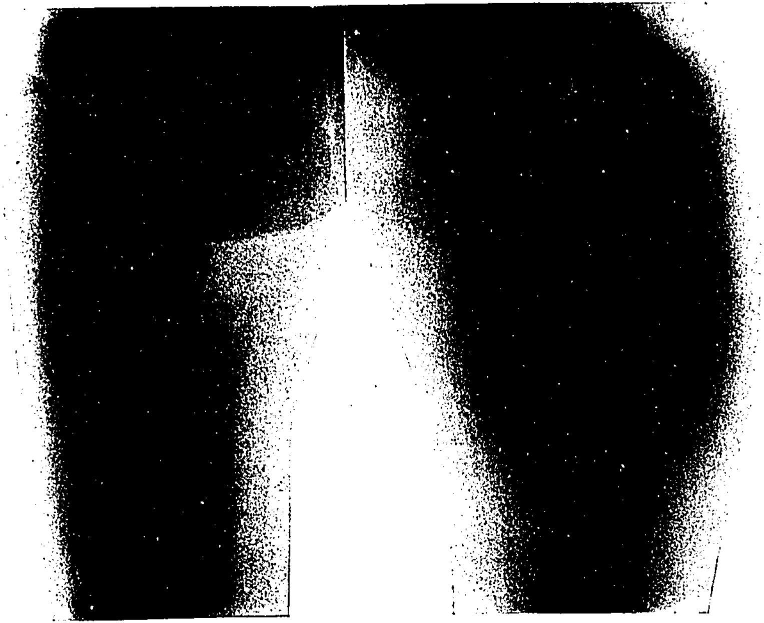


Case XII. Metatarsalgia.

PLATE XI.

Case XIII. Condensing Osteitis in Femur.

PLATE XII.



Case XIV. Subperiosteal Abscess of the Right Femur and Normal Left Femur.

4. *Inflammatory swellings and new growths* (except when bony) have not yet been shown to offer any special features diagnosticating them from normal structures. Bony tumors can plainly be seen, and as the method improves it is to be expected that intracranial and intraspinal osteomata may be discovered and located and possibly even periosteal thickenings due to tubercular, syphilitic, or pyogenic infection. Dead bone cannot as yet be distinguished from living bone, but it is reasonably certain that by greater perfection in detail we shall soon be able to outline the exact position and extent of a sequestrum, this again being made possible by the transparency of the bone-shadow itself; so that, for example, in a case of necrosis of the femur the shadow of that bone and the shadow of a sequestrum contained within it may be superimposed and plainly separable on the skiagraph. Abscess in bone can be made out perfectly.

Comparison of the normal limb with that which is the subject of tubercular or other chronic bone-disease will often reveal the full extent of the latter better than any method of exploration, and in a recent case led me to perform amputation through the hip-joint instead of through the upper third of the femur, the condition found abundantly justifying the procedure.

5. *Fractures and dislocations* at present offer the greatest field for the every-day use of the Röntgen method. It is impossible at this time to present exhaustively the conditions under which it should invariably be used, or to separate them from those in which it is a matter of interest rather than of necessity; but it is safe to say that it will be wise to employ it when possible.

a. In all fractures in or about joints either as a preliminary to the reduction of the deformity, or as evidence that such reduction has been accomplished. These fractures are, for unavoidable reasons, often followed by some limitation of motion and a more or less imperfect functional result. They have, therefore, on innumerable occasions been the basis for suits for malpractice. It will be both a satisfaction and a safeguard for the surgeon if he can see that his work has been accomplished properly and can retain definite evidence of that fact.

b. In doubtful cases or cases supposed to be of great rarity, it will be of inestimable value (Case VII., Plate VI.), both as aiding diagnosis and as demonstrating and recording the conditions present.

c. In cases of old injury in which, as so frequently happens, no reliable clinical history is obtainable and no accurate diagnosis can possibly be made by the ordinary methods. (Cases III., IV., and V., Plates II., III., and IV.)

d. In cases of ununited fracture, both to show the exact position and relation of the fragments prior to operation, the presence or absence of interposing structure, etc. (Case II., Plate I.), and also to show after operation the degree of efficiency of the wire, or of the peg or screw, or of the splint, or other retaining-apparatus. We may frequently determine in such cases whether or not open operation is needed, union often being obtainable, where the fragments can be brought into good position and nothing is interposed, by mere friction and the reapplication of the splint or other dressing.

6. In cases of *excision of joints* at the time when, for example, in the knee it is desirable to demonstrate that bony union has been obtained and in the elbow that it has been avoided. (Case IX., Plate VIII.) (Case V.)

7. In cases of *deformity* of all sorts affecting the bones, their epiphyses, or diaphyses, and requiring careful investigation before surgical interference is declined or advised. (Case VI., Plate V.)

8. In many *obscure cases* of the type of metatarsalgia, in which the demonstration of the cause of the nerve-pain and the indication for surgical treatment are equally clear and convincing. (Case XII.)

ILLUSTRATIVE CASES.

I.—The patient, W. S., was admitted to the wards on January 23, 1896. Seventeen weeks previous to his admission he sustained a compound fracture of both bones of the right forearm. The flesh-wounds healed rapidly, but the bones remained ununited and at an angle, although they were treated by fixation in a plaster-dressing for some time.

The operation showed that the line of fracture was in the middle third of each bone. The extensor carpi radialis was found interposed between the fragments of the radius, where they overlapped one and one-half to two inches, effectually preventing any chance of union. The upper fragment was in extreme supination, while the lower was in extreme pronation.

The fragments of the ulna showed an attempt at the formation of a false joint, the proximal end of the lower fragment containing a cavity in which the distal end of the upper fragment was held. Great difficulty was experienced in getting anything like a proper approximation of the bones on account of the extreme rotation in opposite directions of the two fragments of the radius and because the interosseous space was more nearly obliterated between the lower fragments.

The resected ends of the bones were held in position by wire sutures and the flesh-wounds closed by interrupted sutures. The flesh-wounds healed rapidly, but bony union seems doubtful as yet. The skiagraph shows the position of the bones and the silver sutures in position, and illustrates the ability we now have, without disturbing the wound itself, or the limb, or even the dressings, to obtain accurate knowledge of the exact position of the bones after an operation of this character. Such information might be of the very highest practical importance. It might lead to a change of apparatus, to an alteration in the position of the limb, to a second operative attempt, etc., and it would almost certainly aid in giving definiteness to prognosis and in determining without undue motion of the part the final result as to the presence or absence of bony union.

II.—H. P., aged thirty-three years. On February 7, 1896, the patient was caught in the belt of a pulley and thrown down about six feet. He fell upon his left hand, bending it under him in extreme flexion. The patient was taken to a hospital, which he left seven weeks afterward without the consent of the attending surgeon. On admission to the University Hospital an ununited fracture was diagnosed, with the formation of callus and an attempt at union; preternatural mobility was, however, marked.

The operation showed the condition to be exactly that seen in the skiagraph, the lines of fracture were as they are there shown; a fibrous union existed between the distal end of the upper fragment of the ulna and the proximal end of the lower fragment of the radius. This attempt at union was broken up, and the ends of the fragments were freshened and united by drills, which were left *in situ*. The skiagraph was here of distinct assistance during the operation, enabling me to cut down upon and to remedy the deformity with the least possible disturbance of parts.

III.—C. R. L., aged thirty-six years, was admitted to the University Hospital March 31, 1896, with an ankylosis of the elbow. He gave the following history: In the latter part of January, 1895, he fell down stairs, striking on his elbow. The arm was dressed on a splint in full extension. This was continued for three weeks, when the arm was placed at an angle and dressed on a posterior moulded metal splint. After about four weeks passive motion was commenced, and a little later considerable force was used. The patient continued treatment for about three months longer and then stopped all treatment until he came to the hospital.

The diagnosis of dislocation of both bones of the elbow backward was easily made.

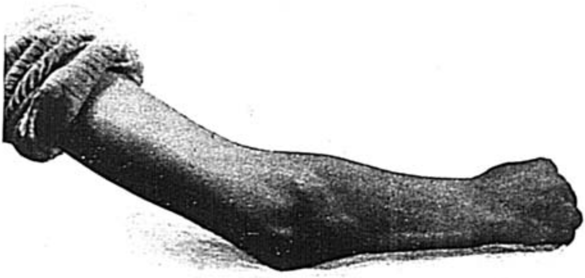
The skiagraph gave an apparently blurred and indefinite outline of the joint, which before operation seemed rather unsatisfactory. The operation, however, showed it to be exactly correct, the joint was dislocated, was ankylosed, and was surrounded by a large amount of dense callus, making excision of the joint with the arm in extension and fixed very difficult. The callus was exceedingly hard and united the olecranon process to the humerus. It was necessary to divide the olecranon and cut it free from the humerus with a chisel. The joint was cut part way through and then broken, thus permitting the completion of the excision.

There can be no doubt that as we acquire greater familiarity with this method we shall be able to recognize exact conditions as shown by different depths of shadow, etc., with much more accuracy. In this instance, for example, the facts were before me prior to the operation, but except that I saw that my diagnosis of backward luxation was confirmed, I got no help from the skiagraph. In future cases of the same sort I shall profit far more by the picture—at least to the extent of anticipating—and, when necessary, providing for the special difficulties of the case. This patient has recovered with a most useful and satisfactory arm.

IV.—F. McD., a carpenter, aged twenty-four years, fell from the roof of a house, a distance of forty-four feet, four years previous to his admission to the University Hospital.

There was a great amount of ecchymotic swelling; a fracture was diagnosed and the arm dressed in a posterior moulded felt splint. It was kept in this position for ten weeks; after this time the patient began by himself the use of passive motion, and succeeded in getting sufficient movement to enable him to pursue his occupation, although the arm was always tender, and cannot be flexed sufficiently for him to reach his mouth.

Two days before he presented himself at the hospital he heard, while at work, a loud snap which was followed by pain and increased disability. The skiagraph shows the normal outline of the bones, with in addition an amount of callus on the coronoid process of the ulna (?) and a free fragment of bone (?) above and external to the head of the radius. (See figure.)



CASE IV.—External view, showing displaced fragment of bone.

This case has not yet been operated upon. It illustrates better than any I have ever seen the uncertainty which still exists as to the interpretation of the skiagraphic picture, and it also shows the obscurity of many of these combined bone- and joint-lesions. I exhibited this patient, with the skiagraph, at a recent meeting of a surgical society. He was examined by several skilful and able surgeons, each of whom reached a different conclusion as to what he saw in the picture and felt in the arm. They all differed from my own view. The case will be reported in full after operation.

V. *Excision of the head of the radius.*—This case, of excision of the head of the radius for forward luxation with limitation of the power of flexion, was sent to the hospital by Dr. D. P. Miller, of Huntingdon; the history was obscure, as a previous injury had made a clear diagnosis impossible.

Excision of the head of the radius was decided upon and the operation was performed; the patient regained the power of flexion, with, however, only a very slightly increased amount of pronation and supination.

The skiagraph, taken after the recovery of the patient, shows the radius after the excision of the head and also an old fracture of the ulna with adhesions to the radius, accounting for the limitation still remaining in the power of pronation and supination. It also illustrates in a most marked manner the great usefulness of the Röntgen photographs in cases of old injury that are sent to hospitals for treatment, without a true history or diagnosis of the condition of the parts at the time of the former accident. The failure to secure a greater amount of pronation and supination was a disappointment to me at the time, and seemed inexplicable. The discovery of the old fracture and its adhesions completely cleared up all doubt as to the cause of the continuing disability and at the same time enabled me to decide that further operative interference was not indicated.

VI. *Curvature of the radius due to arrested development of the ulna at its distal epiphysis.*—E. A., aged fifteen years, came to the hospital for advice in January, 1896. The family history showed one case of tuberculosis, a paternal aunt, but there were no other cases in any other generation. The paternal grandfather had an epithelioma of the lip, which was excised without recurrence.

The patient had had the diseases of childhood, but no severe or protracted illness. The present trouble began in the seventh or eighth year, when a little lump was noticed on the arm and the patient complained of pain located at that point. There was no sign of curvature at that time, it has come on gradually since, while the pain has been inconstant and rheumatic in character, seemingly following a slight cold at each attack.

The patient has fair use of the hand and can write with it and do almost everything needful, so no operation was advised.

The skiagraph and the photograph show very well the condition and appearance of this forearm, and, if functional disability were greater, would serve excellently in locating the proper seat for operation if, for example, excision of a portion of the radius were decided upon.

VII. *Diastasis of the distal epiphysis of the humerus, resulting from a fall on the hand.*—W. McL., aged eleven years, came to the hospital on March 31, 1896, with fracture of the humerus.

The history was of a fall from a wall five feet high to the pavement, striking on the left hand. The patient weighed about seventy-five pounds; he sustained no other injury.

The case was diagnosticated and dressed before the skiagraph was developed, the latter demonstrating the correctness of the diagnosis and showing the position of the fragments resulting from this rare form of epiphyseal separation.

The new record that will now be made and kept of such cases as this will in time alter our statistics entirely as to the frequency of various forms of fracture or of epiphyseal injury. It will no longer depend on the skill and experience of the particular surgeon (though they will be of no less value to the patient than before), but will doubtless soon be made up of irrefutable testimony as to the exact conditions present.

VIII. *Diastasis of the proximal epiphysis of the humerus, with overlapping of the fragments and union in a faulty position.*—S. B., aged sixteen years, fell heavily on the left shoulder, while playing football, in December, 1895. He passed through the hands of two doctors; the condition was then recognized by Dr. E. M. Corson, of Norristown, who sent him to the hospital for operation.

At the operation a longitudinal incision through the deltoid toward the anterior border showed the proximal end of the lower fragment overlapping the upper fragment by about two inches, with firm bony union between the two fragments. The upper end of the lower fragment lay beneath the coracoid process and interfered materially with the function of the joint. The upper portion of the lower fragment was resected, giving the joint free motion. The patient made a good recovery. The skiagraph showed the position of the fragments after the operation and their lateral union in a faulty position.

IX. *The results obtained in excision of the knee.*—This skiagraph shows the union between the femur and tibia resulting after an excision for marked tubercular disease. As in the cases of ununited fracture, it illustrates the advantage which may accrue from escaping the necessity of determining by an attempt to elicit motion whether or not bony union between apposed bones has been obtained. Very often while both patient and surgeon are anxious as to the result of operation it can only be determined positively by the application of a degree of force which is in itself harmful. The progress of the case can be watched if necessary by the use of this method, any displacement of bones immediately remedied, and the final outcome seen without the very least disturbance of the parts.

X. *Foreign bodies in the arm.*—This skiagraph shows a piece of steel in the lower portion of the upper arm, which was easily located by the aid of the skiagraph. It shows, however, as has already been said, merely the relation of the steel to the inner border of the arm, leaving in doubt its relation to the anterior or posterior surface. The former point was easily made out by exact measurement, and, of course, in this case and in this locality, removal was easy. But it might be of vital importance to know the depth of the layer of tissue occupied by such a body. A second radiograph taken laterally would supply this information.

XI. *Bullet in the forearm.*—This was an interesting illustration of the difference in accuracy between the old methods and the present ones in the search for foreign bodies. The bullet (32-calibre, rifle) had entered the upper arm on the outer side, years before. An elaborate dissection had been made some time afterward in the attempt to find it. The patient was annoyed by the knowledge of its presence and complained of more or less vague nerve-pain affecting the whole extremity, no localizing symptoms being present. The arm was large and muscular. The skiagraph happened to include the forearm and by accident the bullet showed on the extreme edge of the plate. It lay on the inner edge of the ulna, partly overlapping the interosseous membrane. While Von Bergmann's warning against meddlesome surgery in these cases is timely and well-founded, it is certain that in this situation there were possibilities of later troubles if by a second traumatism the sharp edge of the missile had been driven against either the nerves or vessels of the part.

XII. *Metatarsalgia.*—Mrs. ——, a patient of Dr. S. Weir Mitchell, had suffered for years from pain about the metatarso-phalangeal junction of the right foot.

The skiagraph shows that as a result of wearing pointed shoes there is a deformity consisting in part of the obliteration of the normal metatarsal spaces, with consequent pressure upon digital nerves and pain, sometimes intolerable. Walking in the bare feet or in stocking-feet as a systematic exercise is, in mild cases, sometimes curative. Resection of portions of the metatarsal bones is indicated in others. In either case the skiagraph is of great advantage as a guide to the surgeon.

XIII. *Condensing osteitis.*—This skiagraph shows the femur of a young adult, a patient of Dr. Pyle, of Wilmington, who has had a tubercular osteitis of the lower end of the femur with necrosis. Following operation the wound healed entirely. The picture was taken some months later. It appears to show distinctly the area of condensing and formative osteitis which followed the operation, and also seems to show that no cavity and no sequestrum remain. Such deductions will, however, become more and more positive as we obtain larger numbers of skiagraphs, both of diseased conditions and of normal ones with which to compare them.

XIV. *Subperiosteal abscess.*—This skiagraph, taken from the diseased right and normal left thighs of a child, shows indistinctly on the right the outline of a very large swelling having every clinical characteristic of sarcoma, occupying its upper two-thirds. Months previously I had made a diagnosis of periostitis in this case. This fact led me to consider the possibility of abscess, although the physical conditions of the swelling seemed most unlike it. The skiagraph also seemed too indistinct in outline to represent a true bony growth, though as yet all this was problematical. At any rate the case proved to be an enormous abscess, stripping the periosteum from the femur throughout its entire length. At the time of operation the child had a temperature of 100° to 101°. It is apparent that even such swellings, while far more indistinct in the skiagraphs than normal bone, and probably not so definite as growths originating in bone, may yet easily be differentiated from the surrounding structures.

I confidently anticipate great improvement in this direction and the extension of the method to the differential diagnosis between abscess and new growths involving deeper portions of the body.

XV. *Foreign body in the œsophagus.*—This case was the first, so far as I know, either in this country or abroad, in which the presence of a foreign body in the œsophagus was revealed by the Röntgen rays. A child, aged two years and five months, a patient of Dr. Taubel, of Philadelphia, had been complaining for ten days of some difficulty in swallowing and had begun to reject all solid food, although it would still take small quantities of milk. Attempts at feeding it with even semi-solids invariably resulted in vomiting. There was no clear history of any foreign body having gained access to its digestive tract, but it was known that a plaything known as a jack-stone was missing from a set which the child had been using. When she was brought to me I sent her at once to Professor Goodspeed to have a skiagraph made, with the result of immediately obtaining the most accurate and definite information. The plate obtained after a three minutes' exposure revealed not only the presence, but the precise location of the body. The following morning, after carefully weighing the chances of the case after œsophagotomy or gastrotomy, I decided in favor of the latter, as the length of time which had elapsed made it probable that the jack-stone had become very firmly lodged and would be difficult to withdraw by the forceps even through an œsophageal wound. The result showed the correctness of this belief. After the stomach was opened a fine rubber explorer was passed through the pharynx and out of the stomach-wound carrying a long piece of stout silk attached to it. The explorer was withdrawn and wads of gauze of various size were tied to the silk; some of these could not be carried either way beyond the jack-stone, but, whether pulled downward through the mouth and pharynx or upward through the stomach, were arrested when they reached it, even although very considerable force was used. Finally, however, the proper size was found and the jack-stone was pulled downward into the stomach, from which it was easily extracted. The mucous membrane was then at once stitched together with a continuous catgut suture and the whole wound was inverted by a continuous Lembert suture. The operation, including preliminary attempts at removal by forceps, took something less than a half hour. The child reacted well, and has entirely recovered.[1]

The propriety of attempting extraction by forceps, guided by direct inspection at the time with the aid of the fluoroscope, was considered by me; but the attempt was not made on account of the presumably ulcerated and inflamed condition of the œsophagus, contraindicating instrumentation in that canal. The method will doubtless prove applicable in the future to many cases seen earlier.

A large number of other cases have occurred in my service, but these are sufficiently illustrative of the extent and variety of the application of this method of surgery.

Professor Goodspeed has kindly prepared the following account of the method by which he secured the excellent and helpful pictures of the foregoing cases:

The apparatus which has been used in the work illustrating this article consists essentially of four parts. The first is a storage-battery of twelve cells, arranged six in series and two in multiple arc, giving an electromotive force of about twelve volts. The second part of the apparatus is a current-interrupter of special construction run by a motor and arranged to give from one to three thousand breaks per second. The contact-points of the interrupter are made of thick pieces of platinum, and on either side are attached the terminals of a variable condenser in three parts to take up the extra current due to self-induction in the coil and thus to make the break more sudden. The third part consists of an inductorium of the Ruhmkorff type, the primary coil of which is attached to the interrupted battery circuit. The secondary circuit is attached to the terminals of the fourth element of our set of apparatus, viz., the Crookes's tube. The tube which has been used in much of the work and found very efficient was made by the Knott Company, of Boston, from a plan made by the writer. It is a glass bulb about four inches in diameter, exhausted to such an extent that under the electric discharge no blue halo appears at either terminal. The glass fluoresces a brilliant green. The cathode or the terminal attached to the negative pole of the secondary coil is a concave aluminum disk about one and a quarter inches in diameter. In the centre of the curvature of this, viz., about three inches from it, is placed the anode, consisting of a flat platinum disk. The wires to which these disks are fastened are sealed into the glass by German enamel and covered nearly their whole length within the tube by this material.

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[1] This case was published in full in the University Medical Magazine for June.

By this means internal sparking is almost entirely avoided. We have several coils capable of giving different intensity-effects. The one which seems best adapted to all grades of work gives a ten-inch spark in air. The exposures required depend, of course, upon various conditions, and were from a few seconds to three or four minutes. This leads us to an important detail in connection with this work, viz., the sensitive plate upon which the negatives are made. We have made many experiments upon various plates on the market and have been associated with Mr. John Carbutt in the development of a plate especially adapted to this purpose. Upon the efficiency of the plate that Mr. Carbutt now makes depends, I feel sure, much of the excellence of the work that we have lately done.

For sharpness of detail it is necessary, of course, to have the part to be skiagraphed as near the film as possible. It is found convenient, therefore, to wrap the plate in two or three thicknesses of thin black rubber-covered cloth, which is quite effectual in excluding all light during the exposure. This plate is then bound tightly to the part with long gauze bandages, film-side to the skin. The Crookes's tube is placed on the other side of the part from one to two feet away, according to circumstances. It is probable that the resultant effect obeys the law of " inverse squares;" so that to produce the same density in the negative in two experiments the times of exposure should be proportioned to the square of the distance of the tube from the plate.

Many details in the manipulation of the various parts of the apparatus have to be attended to continually, and the best results are obtained only when all the various parts are carefully and properly balanced. When the cathode is large the tube seems to be more powerful for the time, but it wears out soon—*i. e.*, its exhaustion gets so high that the largest coil will produce no discharge through it. Under these circumstances it has to be opened and re-exhausted to the proper degree. It is clear, then, that the conditions necessary for the very best results cannot be realized very long at a time.

The fluoroscope, consisting of a screen of cardboard covered with calcium tungstate, is a very useful and almost necessary addition to the equipment. If such a screen takes the place of the photographic plate, and the eye, shielded from external light, be placed behind it, shadows of the bones or foreign bodies can be plainly seen on the screen.

In many simple operations the use of the fluoroscope would be quite sufficient to gain all needed information.